Followed By Physicochemical Parameters And Clogging Index (SDI) Of Treated Water At The Station M'rirt By Multivariate Analysis

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***Abstract*— In order to evaluate the performance of the M'rirt treatment plant for 48 hours, we performed for the first stage a follow several physicochemical parameters and 2nd stage monitoring silt density index (SDI) in function of the turbidity. For this we performed a multivariate analysis, Principal Component Analysis (PCA), Correspondence Factor Analysis (CFA) and multiple linear regressions (MLR).**

It emerges from the results that the operation for 48 hours of the treatment plant has confirmed statistically that the treatment has no effect on the conductivity and chlorides.

To measure the clogging index of filtered water has revealed that there is no correlation between SDI and turbidity below 1 NTU.

However, the water filtered through the M'rirt processing station is a limit in terms of quality Fouling Index. The significance of this paper falls on the statistical study of the analytical method, where all the uncertainty contributions involved in the process have been considered.

Keywords— wastewater treatment plant M'rirt, Quality of drinking water, PCA, CFA, MLR, SDI.

I. INTRODUCTION

Water stress facing the world and the exploration of new water resources, many scientists are looking at the issue to try to find solutions to clean water and make it drinkable. Adding to the lack of water, pollution of it requires very different each time new investigations and the development of specific processes to clear all sources of water for human use [1].

We focus in the sand filtration technique (the Mrirt station) as an essential phase for the treatment of water, this process is known well suited to rural areas, since it presents a good quality treatment, a simple and relatively low maintenance operation. [2].

Supplying the population with drinking water quality meets standards or WHO guidelines remains for governments' paramount concern. With the development of urbanization and changing consumption patterns, the demand for water is changing dramatically in terms of quantity and quality [3].

The municipality of M'rirt located in the eastern part of central Morocco, near the western edge of the Middle Atlas Causse M'rirt, a small town located at 1113m above sea level, is halfway between Azrou and Khenifra; it is also connected to Meknes by road Adarouch had in 2004 a total population of 35.196 inhabitants. The population increased from 13856 inhabitants in 1982 to 25942 inhabitants in 1994, this fairly rapid increase in population has led to think a source of drinking water because of insufficient quantities of water supplied to it the national Office of water and electricity (ONEE-MOROCCO) constructed a water treatment plant supplied from of Oum Errabia River to supply the city of M'rirt by drinking water. In response to the drinking water scarcity, the national Office for Potable Water has used the classical treatment based on coagulation-flocculation for water treatment of Oum Errabia River, mainly dedicated to remove suspended the matters existing in the river waters.

Among the various coagulation agents identified (metal salts, polymerized metal salts and products of natural origin), ferric chloride $FeCl_3$ and Aluminium sulphate $Al_2(SO_4)_3$ are distinguished by their availability and applicability [4].

The treatment monitoring at the treatment plant of M'rirt is conventional treatment which includes: Screening-settling-pre-chlorination-Coagulation / Flocculation- decantation and Filtration. This treatment is based on the physico-chemical technique that is coagulation / flocculation.

The aim of our study was to evaluate the performance of the M'rirt treatment plant for 48 hours, performing for the first stage a follow several physicochemical parameters and 2nd stage monitoring fouling index (SDI) as a function of the turbidity of the treatment plant.

II. MATERIALS AND METHODS

A. Physico-chemical analysis of waters in the M'rirt treatment plant

The physicochemical analysis concerned various parameters (table I).

The conductivity was measured by a conductivity measuring cell WTW 82362 cond 340i/SET adapted to a type conductivity Crison 522 Conductimeter kind. The temperature measurement was performed by ion meter type WTW 82362 Cond 340i / SET has adapted a conductivity types Crison Conductimeter 522. The measurement of the turbidity of the water was determined with a turbidimeter type Hach Turbidity brand, model 2100AN [5] using the effect of Opacimeter. pH measurement was performed with a pH meter type HI 8424. The analysis of these parameters is carried out by a volumetric assay using hydrochloric acid as titrant phenolphthalein as a color indicator for TA and methyl orange as a color indicator for the TAC agent. The results are given in meq/l or in °F (AFNOR T90-036). Determination of Chloride by the volumetric method mercuric nitrate of Charpentier Volhad [6].

SDI (Silt density Index) is used to estimate the potential fouling caused by organic or inorganic suspended solids and colloidal. Measuring Kit Fouling Index (see following schematic), Electronic Stopwatch, 0,45µm Membranes.

The clogging power is given by the equation:

P (%) = 100 * (1 - t 0 / t)

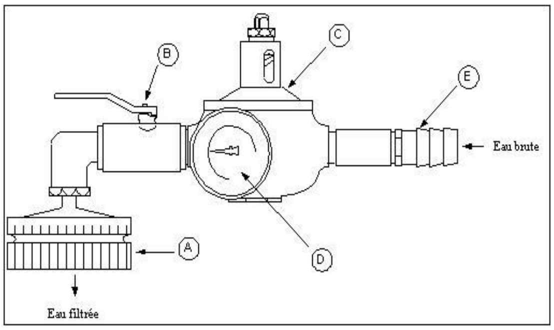
*Calculate Pt = t15:

If P> 80% t = t15, recalculate t = t10.

If P> 80% t = t10, recalculate t = t5.

The fouling index is given by the relationship:

IC = P (%) / T with (T = total measurement time: 5, 10 or 15 minutes depending on the selected time)



Schematic of the measurement kit Fouling Index

Assembly comprising connecting piece (E), pressure reducing valve (C), pressure gauge (D), isolating valve (B) and membrane support (A)

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B. Statistical analysis

Data processing and multivariate statistical method of all quantitative analyzes of the water has been treated by multivariate statistical study XSLAT software to study changes in water quality. For this we performed a multivariate analysis, Principal Component Analysis (PCA) and Correspondence Factor Analysis (CFA) which are useful statistical tools to summarize all the information encoded by the physicochemical parameters indicating the water quality [7].

C.Multiple linear regressions (MLR)

The multiple linear regression statistics techniques are used to study the relation between one dependent variable and several independent variables. The multiple linear are generated using the software XLSTAT, version 2009, to predict . The optimal number of components (N) is employed to do validation MLR analysis to get the final model parameters such as correlation coefficient R2, standard deviation (S) and Fischer test value (F) [8].

D. Description of the treatment plant of M'rirt

Description of region

M'rirt (Berber: مريرت) is a city of the Middle Atlas in Morocco, it is the second municipality in the province of Khenifra, 30 km in the north of khenifra. It is at 1113m altitude (figure 1). It's urban development is due to the presence of rich mineral resources of Jbel Aouam, Ighram Aoussar , Sidi Ahmed, Tighza which is extracted lead, zinc, silver, gold and tungsten. Its operations back to the Middle Age in Europe. The souk held every Thursday attracts a large number of people, especially the inhabitants of the surrounding countryside. The souk is located at the foot of the hill Boulouhouch northeast of the city (ONEE – Morocco).

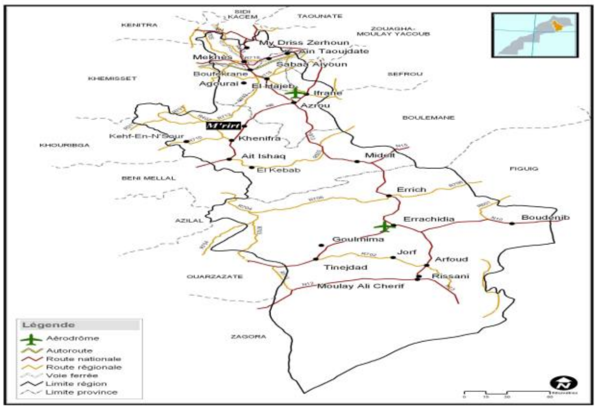

Fig 1: ***Geographical location of the city of Mrirt***

- *Climate*

The climate of this region is continental which influences the seasonal temperature change, even daily. In a harsh winter followed by a hot summer. Rainfall varies by region between 400 and 700 mm/year on average.

Precipitations in winter as snow are abundant on the set of Bekrite, cervical Zad and the High Atlas. The combination of temperature and rainfall is likely to create favorable conditions for vegetation belts: thus, we shall succeed depending on altitude, forest Kharroubier or carob, holm oaks and cedars (Cedrus atlantica), junipers, Tetraclinis- articulata or Thuya (Elaaraar)

- *Steps of conventional treatment*

Each treatment systems consist of a rapid mixer, (flocculator – Decante) and a battery of four filters (Fig. 2).

Rapid mixer

At this step is done mixing the reactants treatment with raw or settled waters and in turn leading to a destabilization and coagulation of particles generating turbidity. The reactants of treatment which can be injected at this level are chlorinated water, Aluminium sulphate $Al_2(SO_4)_3$, polyelectrolyte and lime.

Floculator- Decanter

- The clarification process carried out at this treatment plant is based on integrated flocculation- decantation. The plant has two circular clarifiers type scraped sludge recirculation, to combine the two stages.
- Flocculation is carried out in the central column of settling, this one allows a 20 minutes residence time, it is provided by three harrows at variable speed.
- Decanting is carried out in a circular decanter sludge scraper operating at a Hazen speed of 1.3 m/h and providing a residence time of 2 hours. The decanter is equipped with purge sludge which operates in automatic and manual mode.

Filtration

The plant is equipped with four filters with surface area of 10.6 m^2 each operating at a filtration rate of 5m/h at full flow. Washing is done in two phases, air-water and water alone. Figure 2 explains the pattern of drinking water treatment plant of M'rirt.

The characterization of the raw water is a must step before each treatment. The physicochemical parameters of the raw water of M'rirt plant are as follows (table I).

Disinfecting

Drinking water, according to the Moroccan standards, should be disinfected by the active free chlorine at the outlet of the treatment plant and contain a bacteriostatic agent.

The Disinfection is the final stage of treatment to prevent transmission of bacterial and viral diseases waterborne. It is made after the filtration to inhibit any biological/bacteriological reviviscence in the reservoirs and networks.

TABLE I: PHYSICO-CHEMICAL PARAMETERS OF THE INPUT STATION

Temperature (°C)	7.5 to 25
pH	8.10 to 8.35
Conductivity (µS/cm)	505 to 2410
Turbidity (NTU)	4.77 to >4000
Chlorides (mg/l)	120.7 to 727
TAC (meq/l)	2.7 to 5.2

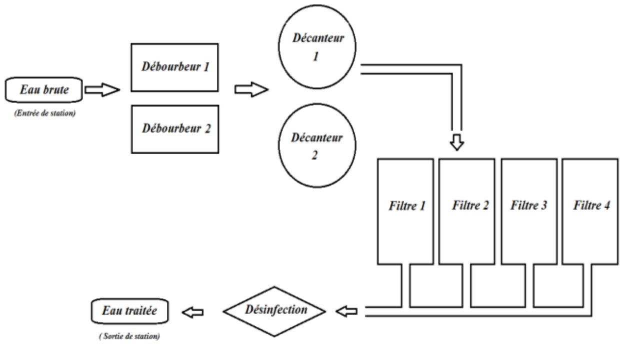

Fig.2: **Block diagram of M'rirt drinking water treatment plant**

III. RESULTS AND DISCUSSION

Descriptive Statistics

Results of monitoring the physico-chemical parameters: pH, conductivity, chlorides performed at the Mrirt treatment plant for nine measurements (table II).

Table II: Descriptive analysis of physicochemical parameters - measurements

Parameters	Minimum	Maximum	Moyenne	Ecart-type
pHM1	7.580	8.060	7.680	0.160
pHM2	7.500	8.150	7.631	0.219
pHM3	7.510	8.050	7.613	0.188
pHM4	7.540	8.030	7.646	0.166
pHM5	7.590	8.030	7.673	0.152
pHM6	7.600	8.130	7.696	0.179
pHM7	7.580	8.150	7.678	0.197
pHM8	7.540	8.000	7.625	0.158
pHM9	7.700	8.150	7.785	0.149
CondM1	1932.00	1953.00	1939.250	6.541
CondM2	1812.00	1870.00	1840.750	23.371
CondM3	1906.00	1964.00	1934.375	17.221
CondM4	1918.00	1948.00	1933.750	10.444
CondM5	1795.00	1861.00	1811.250	21.285
CCondM6	1841.00	1908.00	1884.750	20.415
CCondM7	1881.00	1914.00	1903.000	10.902
CCondM8	1824.00	1887.00	1864.875	20.684
CCondM9	1825.00	1832.00	1827.750	2.375
ClM1	571.55	578.65	574.876	2.213
ClM2	537.32	578.65	571.264	14.035
ClM3	571.55	578.65	575.098	2.324
ClM4	571.55	578.65	574.655	2.069
ClM5	573.32	580.42	576.630	2.329
ClM6	571.55	580.42	576.628	3.461
ClM7	571.55	583.97	579.313	4.018
ClM8	560.90	568.00	563.784	2.991
ClM9	575.00	578.60	576.350	1.273

pH, (Cond)Conductivity,(Cl-) Chlorides. Mi: from 1 to 9 measurements

- Graphical representation contingency table 3D view according to Fig. 3.

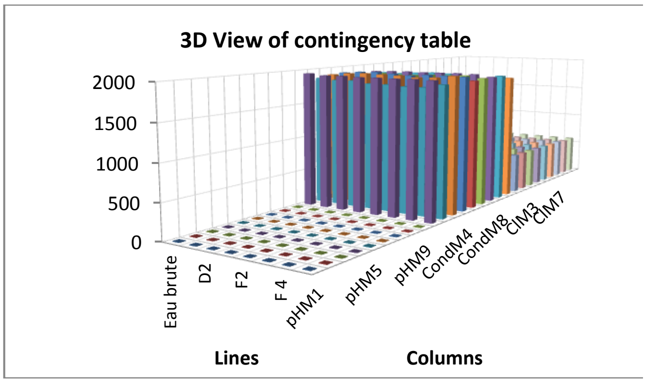

Fig 3: Graphical representation contingency table view 3D

Principal Component Analysis (PCA)

The first three principal axes are sufficient to describe the information provided by the data matrix. Indeed, the percentages of variance are 36.57% and 30.57% for the axes F1 and F2 respectively (Fig3). The total information is estimated to a percentage of 67.14%. The principal component analysis (PCA) [9] was conducted to identify the link between the different variables.

Cartesian diagram (PCA)

The Cartesian diagram PCA (Fig.4) provides information on two groups:

G1: Represents the different measurements of the pH of the raw water which varies depending on the treatment**.**

G2: Represents the different measurements of conductivity and chlorides of raw water and treated water.

The **G1** group could be explained by the type of treatment that has no apparent effect on conductivity and chloride concentration, by against group 2 there was a decrease in pH at decanters and filters with a slight increase after disinfection.

Measure 9 (pHM9) is explained by a decrease in pH after treatment and is in strong negative correlation with the conductivity measure 9 (condM9) according to the Cartesian diagram (Fig. 4).

The CondM4, condM6 and CondM7 measures are also strongly correlated negatively with respect to measures of pHM4, pHM6 pHM7 and this could explain the position of conductivities unchanged after treatment at the Decanter filter (Fig. 4).

Monthly values of the pH range between 7.5 and 8.150 exhibit significant variation.

The pH values are slightly basic to neutral and expressed alkalinity compared to decanters and different filters. The pH values are in agreement with the potability standards [1].

The conductivity provides information on the overall mineralization [10], it varies from 1932 to 1953 $S.cm^{-1}$ The values obtained express an average mineralization accentuated in filters from **F1, F2, F3 and F4**.

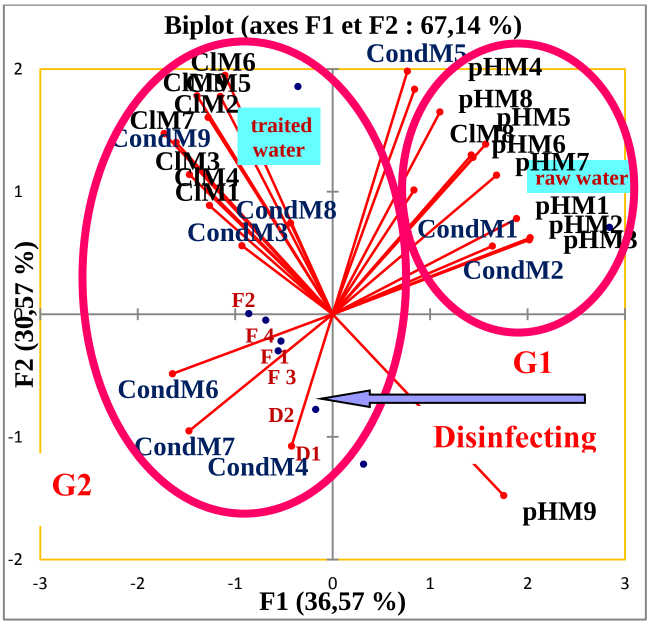

Fig 4: Cartesian diagram (CPA) showing the disinfection of raw water to the treated water

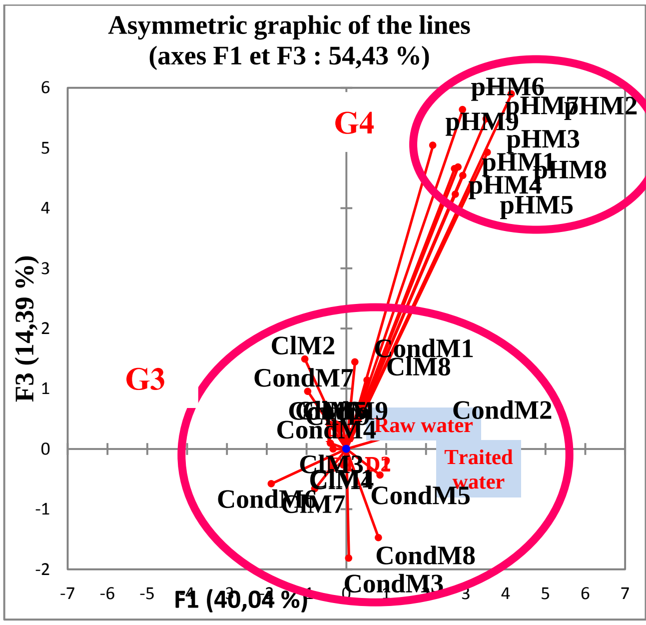

Fig 5: Cartesian diagram (CFA) showing the disinfection of raw water to the treated water

Correspondence factor analysis (CFA)

The first three principal axes are sufficient to describe the information provided by the data matrix. Indeed, the percentages of variance are 40.04% and 14.39% for the axes F1 and F3 respectively (figure 5). The total information is estimated to a percentage of (54.43%). Correspondence Factor Analysis (CFA) was conducted to identify the link between the different variables.

Cartesian diagram (CFA)

We remark after (Fig.5) that the conductivity and chloride concentration are unaffected by the type of treatment which is justified by the **G3** Group between raw water and treated water. By against there is a decrease in the pH level (decanters - filters) with a slight increase after disinfection as the **G4** group located away from treated water and raw water.

Measurement SDI (Silt Density Index)

Figure 6 shows the change in turbidity as a function of treatment (decanters-filters) for two days in a series of steps in a range of from 8:00 SDI.

Note that the treatment for 48 hour monitoring of turbidity meets the standard of 5 NTU and 0.5 NTU [11].

For M1 and M2 of the SDI measurements indicate that water is little clogging kind in relation to other measures **M3, M4** and **M5** are not clogging.

One of the conclusions, it will confirm that the increase in turbidity does not involve the systematic increase of SDI depending on the range of different measures.

Fouling Index showed that there was no correlation between the SDI and the turbidity is less than 1 NTU (Fig. 6).

The SDI provides an indication of the amount of suspended particles in water; but it has allowed us to confirm a good performance at the M'rirt station.

Table III: Results Measurement of SDI (Silt Density Index**)**

	SDI (%)	Clogging index	Turbidity (NTU)	T°C	pH
M1	70.73	4.71	0.24	23	7.76
M2	76.64	5.10	0.23	21	7.88
M3	41.93	2.79	0.29	27	7.73
M4	40.62	2.70	0.24	24.5	7.66
M5	21.62	1.44	0.33	19.5	7.78
M6	22.22	1.48	0.25	19.5	7.68

Mi: Measurements

*Figure 6 shows us the evolution of fouling index based on turbidity following Table III**.**

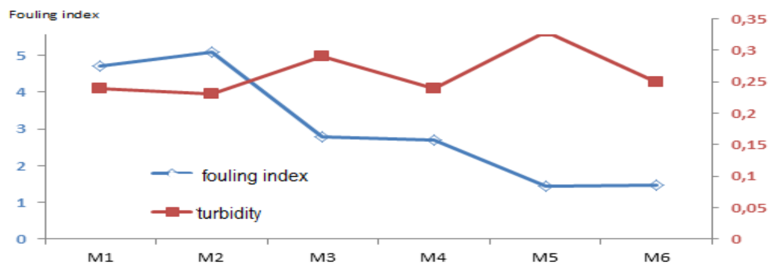

Fig. 6: Evolution of the fouling index based on turbidity

Modelling the variable Treated water
Multiple linear regressions (MLR)

To propose a mathematical model and quantify the physical and chemical effects of Mrirt station; we made the analysis from 3 physico-chemical variables corresponding to the different filters and Decanters (**D1, D2, F1, F2, F3, F4)**, progressive multiple regression. This method uses the coefficients R, R^2 and F values to select the best performance of regression. Where R is the correlation coefficient; R² is the coefficient of determination; MSE is mean squared error; F is the Fisher's F-statistics. Treatment with multiple linear regression is more accurate [12].

The equation model is written:

Treated water = 0.635 + 0.374. Raw water + 0.514*D1 -1.009*D2 + 2.927*F1 -0.793*F2 -2.325*F3 + 1.318*F4

R= 0.999 F de Fisher = 51148.245 Pr > FWith P <0.0001 the result is highly significant because the treated water depends on all (Decanters-filters) into play at the Mrirt treatment plant and

$F_{(7,19)}$ = 51148.245 (table IV).

This could be explained by a good performance at the station because there is no clogging in the filters.

Table IV: Analyses of variance

Source	Ddl	Sum of squares	mean square	F de Fisher	Pr > F
Model	7	16840571,174	2405795,882	51148,245	< 0,0001
Residus	19	893,679	47,036		
Total	26	16841464,854			

Statistique de Durbin-Watson

Evolution of different parameters pH, conductivity, chlorides according to samples of treated water, raw water and the treated water model.

For different pH measurements during 48 hours, depending is observed (Fig.7) that there is a decrease in the pH level of thetreated water.

While for conductivity and chloride concentration, the curves of the raw water, treated water and treated water model are almost confounded what might explain that the type of treatment does not affect the raw water figure 8 and figure 9 [13].

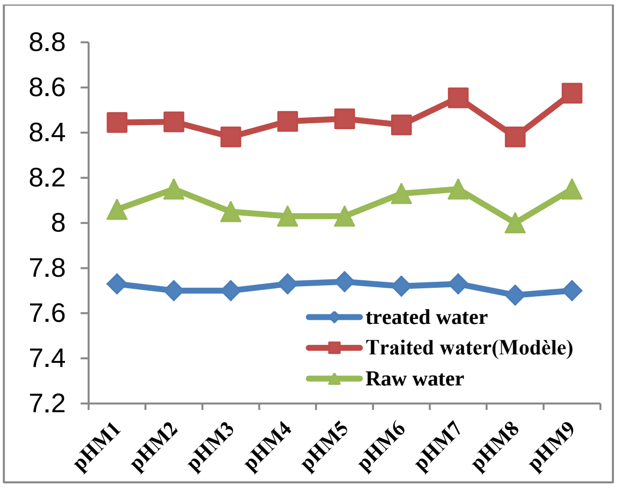

Fig. 7: Evolution of the pH-Measurement of raw water, treated water and treated water model

V.CONCLUSION

The study carried out in the factory of drinking water treatment M'rirt allowed us to characterize the quality of the river Oum Er-Rbia river water and understand the main obstacles of each transaction processing chain well all structures.

The statistical study in PCA and CFA has confirmed that:

• The operation of 48 hours from the treatment plant showed that the treatment had no effect on the conductivity and chlorides.

Multiple linear regression (MLR) gives a correlation coefficient R = 0.999 which justifies the good performance at the station for drinking water.

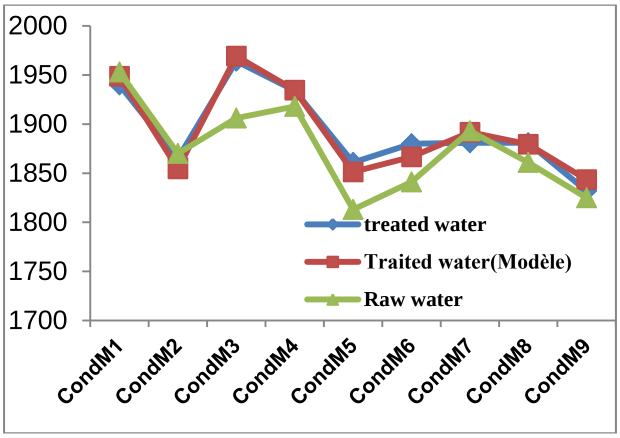

Fig.8: Evolution of the Conductivity-Measurement of raw water, treated water and treated water model

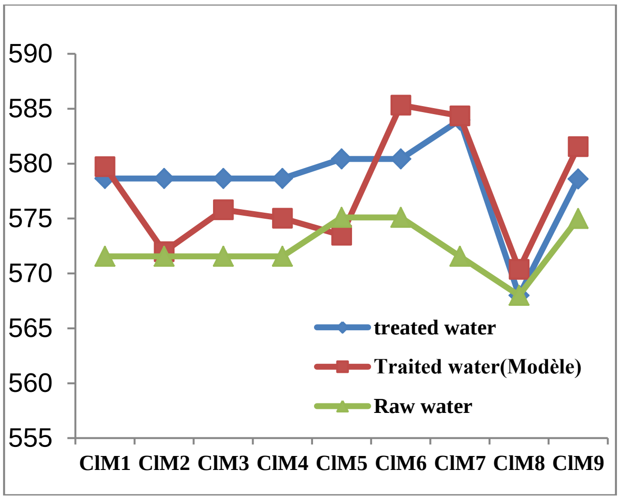

Fig. 9: Evolution of Chloride-Measurement of raw water, treated water
and treated water model

• Measurement of fouling index filtered water revealed that there is no correlation between SDI and turbidity below 1 NTU.

• The water filtered by the M'rirt processing station is a limit in terms of quality Fouling Index.

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